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Employment of Women in the Manufacture of Small-Arms Ammunition

One of a series of reports on women's present and possible employment in war industries, based on field surveys by Women's Bureau investigators since early spring of 1941 (issued first in mimeograph). A report on the actual employment of women in the first three months of 1942 will follow.

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INTRODUCTORY

Ammunition for small arms is of major importance in the aircraft defense program. A single airplane in firing action equipped with eight or more machine guns is reported as pouring out a stream of 1,200 rounds of ammunition a minute from each gun. With tens of thousands of planes carrying machine guns, the demand for small-arms ammunition is potentially prodigious. Manufacturers of ammunition for small arms (hand and shoulder weapons and machine guns and automatic weapons of all sizes up to .50 caliber) have modernized and revamped their old plants in the East and are to operate new Government-built plants in St. Louis, Lake City (near Kansas City), and Denver. The Frankford Arsenal has doubled its personnel in small-arms ammunition several times since 1939. Further, many of the Government contractors are furnishing component parts or complete rounds of small-arms ammunition.

Since the small-arms ammunition industry has a small product, a standardized one as to operations and machining, and one which requires considerable care and attention to detail, women have been used extensively, and as the new plants get into production many more women will be employed in this branch of the defense program. In the Government arsenal at Frankford approximately 40 percent of the productive workers in 1941 were women, and as the dilution of labor increases, women undoubtedly will constitute a considerably larger proportion.

Women comprise a much larger proportion of the munition makers abroad than in the United States. In the London Times of May 11, 1941, a representative describing a visit to the new Royal Ordnance plant in Wales reported that 80 percent of the workers were women. None had more than 7 months' experience and the majority had less. A supervisor expressed the opinion that a typically intelligent girl trained in the factory was as efficient at her work after 6 months as the average boy who had worked longer.

SMALL-ARMS AMMUNITION

Ammunition for small arms is less than 1 inch in diameter and the most common types and calibers are .30, .45, and .50. Caliber is the diameter of the bore or cylinder of the weapon from which the cartridge is expelled and is stated in one-hundredths of an inch. The parts of a round of small ammunition include (1) the bullet or projectile, which is a metal slug or core enclosed in a light gilding metal jacket, and (2) the cartridge case, which holds the primer and the propelling charge and when assembled with the bullet makes the com-

[1] As of early months of 1941.

plete unit. The primer is a small loaded cup set in the base or head of the case which explodes when struck by the blow of the firing pin and ignites the propellant, which ejects and dispatches the bullet from the weapon.

The types of bullets are: "Ball" for use against persons and light targets; "armor-piercing" for attacking objects heavily reinforced with armor plate, concrete shelters, and other bullet-resisting targets; and "tracer" for observation and incendiary purposes. The ball bullet has a lead alloy or slug or soft steel core, the armor-piercing has a hard core usually of tungsten-chromium steel, and the tracer has a compressed igniting and pyrotechnic charge which gives a bright flame and makes the path of the bullet visible or may ignite the object which it strikes.

The findings of this report are based chiefly on a survey in 1941 of occupations of men and women in a Government arsenal which for many years has manufactured small-arms ammunition and tends to establish the methods and standards for this industry.

Summary of the Principal Operations in the Manufacture of Small-Arms Ammunition and the Possibilities of Extended Use of Women

	Sex of operatives (M—men, W—women)	*Extension of women's employment*
Bullet Manufacturing:		
Bullet jacket:		
Drawing (several draws)	M	Could be substituted in part for men.
Annealing, pickling, and washing.	M	Not suitable.
Trimming	M and W	Proportion could be increased.
Bullet point or core—		
Melt and ingot molding	M	Not suitable.
Extruding and forming	M	Do.
Washing and drying	M	Do.
Bullet assembly	M and W	Could be used entirely.
Tracer bullet charging	M and W	Proportion could be increased.
Case Manufacturing:		
Drawing (several draws)	M	Not suitable.
Annealing, pickling, and washing.	M	Do.
Polishing	M	Do.
Pumping, pocketing, and heading.	M	Do.
Trimming	W	———
Head turning	M and W	Could be used entirely.
Body and mouth annealing	M and W	Do.
Tapering	W	———
Chamfering	M	Not suitable.
Primer inserting	W	———
Primer:		
Blanking and forming cup and anvil.	M	Could be substituted in part for men.
Shellacking strips for foiling	W	———
Pellet forming	M	Could be substituted for men.
Foil and knock out	W	———
Inserting of anvil	W	———
Press anvils into primer cup	M	Could be substituted for men.
Primer inverting	W	———

	Sex of operatives (M—men, W—women)	*Extension of women's employment*
Cartridge Assembly:		
Loading machine	M and W	Could be used entirely.
Inspection—Visual, Gage, Machine	M and W	Do.
Packing and Labeling	M and W	Proportion could be increased.

TRAINING

Most of the work in the manufacture of small-arms ammunition is carried on by automatic machinery and only short training periods are needed. All the training can be secured on the job under the tutelage of another operative; 3 to 6 weeks would seem sufficient for a learning period with a highly specialized and mechanized set-up.

BULLET MANUFACTURING

Bullet jacket.

The light gilding metal jacket which covers the core of a bullet is formed by a series of drawing operations similar to those on the cartridge case, except that smaller presses are used. Men are exclusively used for these operations, and though the tending of machines requires little skill and effort, one operator cares for as many as five machines and there is considerable moving of parts in process, filling feed hoppers, and moving finished jackets, all of which is manual work. With further dilution of labor, and providing that additional "movemen" are employed for heavy work, women could operate the drawing presses for bullet jackets. The jacket between drawing steps is annealed, pickled, and washed several times in rotary electric furnaces and revolving drums. This work is all done by men and because much of it is of a heavy manual nature it would not be suitable for women.

Trimming was the only process on the bullet jacket which employed women as well as men. The trimming was done on a special horizontal spindle machine which was simple in operation and required only a short training period. It would seem that women might do all the trimming of bullet jackets.

Bullet point or core.

Handling and feeding heavy bars of steel or heavy reels of lead to automatic machines which require the attendance of skilled set-up men does not require many workers and apparently does not offer any possibilities for the employment of women.

Bullet assembly.

The assembly of the bullet, the pointing or nosing of the jacket, the inserting of the slug, and the finishing operations employ both men and women. Women in a Government arsenal are employed on the .30- and .45-caliber ball and armor-piercing bullets, while men are assembling the .50-caliber bullets and the tracer bullets. Two types of automatic machines are used, the older dial type and the newer straight-line assembly press. The pointing or nosing, inserting of the slug, profiling, sizing, and canneluring are progressive machine

processes, and the work proceeds automatically from one station to the next so that the operator merely watches the operation of the machine and sees that an adequate supply of parts is on hand and that all parts of the machine are working properly. Men adjusters condition and set up the machines. It seems that women might do all the work of bullet assembly.

On some of the bullets a special cannelure must be machined separately. A cannelure is a groove on the bullet which serves as a seat when the bullet is assembled into the case. On the .30-caliber bullets with the extra canneluring, this is a wholly automatic process and requires only the setting-up of the machine and the filling of the hoppers, so men are used. On the .50-caliber, the bullets are hand-fed by women.

Cleaning and polishing.

The assembled bullets are rumbled in drums filled with sawdust to clean and polish. This operation entails heavy lifting and is suitable only for men.

Tracer charging.

Tracer bullets must be charged with tracer (a pyrotechnic powder) and igniter mixture. The bullets are placed in die blocks, topped with die-funnels, passed on by conveyor belt to the charging machine, which automatically weighs and compresses the powder charge, and then moved on to the ejecting machine operator, who inspects the charge and ejects the bullets with a press from the die blocks. Usually there are five operators to a tracer-charging group. On the .30-caliber tracer bullets, women are employed for seating the bullets in the die block, and placing the funnels. Other jobs on the .30-caliber and all jobs charging the .50-caliber tracer bullets are loaded by men.

While it seemed that women might do all the jobs on the charging of tracer bullets, there are certain conditions of employment which would require that women of more than average strength and stability be selected. The die blocks are moved on conveyors but they must be handled, lifted, and pushed about on the work bench, and since they weigh as much as 14 pounds apiece and some of the men workers handle as many as 30 a minute, there are elements of cumulative fatigue involved. While the amount of powder allowed in the charging machine is limited, and there is little hazard of a major nature, there may be an occasional flare-up from accidentally ignited powder, with a possibility of burns, and the operative must be emotionally stable and able to continue at work without quailing.

CARTRIDGE-CASE MANUFACTURING

The cartridge case which forms the base of the complete round is made of one piece of brass by several drawing and machining processes. The case when assembled contains the primer, the propellant powder, and the bullet in a waterproofed, airtight unit.

Drawing operations.

A small heavy brass cup of prescribed size and weight for the various calibers, which has been drawn by the brass fabricators, is

the starting point for the further drawing operations. There are several drawing, bumping, pocketing, and heading operations in the shaping and elongating of the cases which are performed on large crank presses by men. To permit further draws and to secure the required physical qualities of the metal, the cases are annealed, pickled, and washed several times during the drawing and machining. The annealing processes are considered unsuitable for women because they involve moving trucks filled with cases, heavy lifting, and general manual labor to which women are not suited. In the Government arsenal visited the sentiment was that the drawing and allied operations were not suitable or desirable jobs for women. The draw-press operators, in addition to tending their presses, keeping the feed lines clear, and making visual and gage inspections of the cases in process, must do manual work moving filled carts, fill the coolant reservoir with soapy solutions, keep the hopper filled with cases—the last two requiring heavy lifting—and occasionally must mop up the floor around the presses, which becomes spattered with oil and coolant. Most of the time the operator of a drawing press must stand. Also, the draw-press room resounds with the din of the presses, the floors are slippery, and in spite of guards on the presses there is danger of finger injuries. While women might be used as draw-press tenders, it seemed of slight feasibility. The training period is short, a few weeks at most for draw-press operators, so women in case of emergency needs might be put on without any significant loss of time for a learning period.

Trimming.

After the third and fourth drawing operations, the mouth (top) of the case is trimmed on a special horizontal spindle machine with rotating cutters. Women are employed for trimming and the learning or training period was reported as short, only about 1 week.

Head-turning.

The head or base of the cartridge case holds the primer seat, the vent hole, and the extracting groove. An automatic screw machine cuts the extractor groove, machines the base, and countersinks the primer pocket as a continuous operation. The operator fills the hopper, watches the feeding. and makes occasional visual and gage checks of the cases. Machine adjusters set up and service the machines. Both men and women serve as operators, the former on the .50-caliber, and the latter on the .30 and the .45. Little training is required for the operation; movemen or truckers usually are promoted to head-turning. The men operators usually assist with the moving of trucks. Women undoubtedly might do all the head-turning with the help of additional movemen for filling the hoppers and trucking off the finished work.

Body and mouth annealing.

Before the mouth of the case is tapered, it must be annealed to secure the necessary physical tensile properties. This annealing process is carried on by feeding the cases on a worm-driven conveyor with the tops of the cases passing through a series of flaming gas jets while the heads are immersed in a water bath. The cases are hopper fed and the operator is a machine tender watching the feed

and visually inspecting the process. Both men and women tend these machines and there seems no reason why women cannot do all such annealing.

Tapering.

The body of the case at the mouth is tapered a bit to permit easier extraction of the case after expansion by the expulsion of the bullet. Two successive tapering operations are processed on a straight-line double-action press, which has automatic feed and controls. Women in a Government arsenal were operating all the tapering machines, three machines being assigned to each operator.

Finish trimming.

After tapering, a final trimming of the mouth is next in sequence and women do this operation. These machines also are of an automatic type and one woman may operate as many as four machines. The operator tends the feeding of the cases along a magazine track, watches the operations, and gages the trimmed cases at certain intervals. The operators walk from machine to machine and also make spot inspections of the cases to be fed into the machine for defects such as dents. The cutting parts of the machine are shielded, but there are some flying chips which afford a slight possibility of injury.

Chamfering.

The final operation on the mouth of the case is chamfering the edge to put a slight flare which eases the insertion of the bullet. Chamfering requires a certain amount of mechanical ability in making machine adjustments, changing and sharpening the cutting tools when needed. Otherwise the operation proceeds on an automatic basis, the men watching the feeds, occasionally inspecting the cases much as in trimming. Women who are experienced in operating machines such as milling machines, grinders, and turret lathes could do this operation.

Inserting primers, cutting the vent hole, and waterproofing.

The last operation on the cartridge case before it is ready for the final assembly with the bullet is inserting the primer, cutting the vent hole, and waterproofing. The primer is made up of a cup, a percussion pellet, foiling disk, and anvil which have been assembled before insertion in the case. The vent hole is an opening in the head of the primer pocket through which the flame from the primer passes into the case and ignites propellant powder stored there. All the operations of this final process are carried out on a straight-line automatic crank press which has nine automatic stations which chamfer, punch the vent holes, inspect for "no-hole," seat the primer, crimp the head of the case to the primer, and waterproof with a drop of colored varnish between the primer and the case head. The job, again, is the tending of an automatic machine, and women operators tend one or two machines. The training period is not more than a couple of weeks.

If the machines are not kept clean there is a possibility of an occasional flare-up from small particles of primer mixture that may have accumulated in the stations of the machine, but this is of rare occurrence.

PRIMER MANUFACTURING

The primer for small arms is a tiny brass cup which contains the pellet charge pressed to a foiling disk and a tiny anvil through which the flame from the ignited pellet passes into the vent hole in the cartridge case.

Forming of the primer cup and anvil.

Small automatic presses blank and cup the parts for the cup and anvil. Men set up and operate these presses. If women had the skill necessary to make the set-up, or if set-up men were employed, women could operate the machines.

Pellet forming.

The pellet is a small explosive wafer which is placed in the cup under the anvil. The forming of this pellet is a hazardous job and the men doing this work in a Government arsenal are classed as explosives operators. The primer mixture is rubbed into holes on a charging plate with a strip or piece of rubber, and pressure is applied to the charging plate to form the pellets. The work is carried on in a shielded booth, with a glass shield that is pulled down while the pellets are being pressed to enable the operator to watch the pressing process. There is an explosive and fire hazard in this process and precautions are taken to safeguard against the spreading of fire from these booths or boxes. Only a few men are employed on this work, and except as hazardous jobs are undesirable for all workers there was no reason from the standpoint of strain and skill required why women could not do the work.

Primer foiling and anvil inserting.

Strips of foiling paper to be made into foiling disks are shellacked by women. Women also operate the press which cuts or punches the disks and presses them down over the primer pellet.

The small anvils are placed in the primer cups by women. It is a simple hand operation and requires no training.

The anvils are next pressed into the primer cup on a toggle press. Men are used in the Government arsenal on this job but the work is light and simple and might as well be done by women.

All the jobs in connection with primer foiling and inserting of the anvils, and in primer inverting, are light work and can be done as well by women. The draw-back of the job is that there is an ever present though slight hazard of sudden fire explosion. This, however, is a strain for men as well as for women and the reactions and emotional stability of operatives probably are more affected by individual differences than by the sex of the worker.

Primer inverting.

After the primers have been made they are tumbled from a hopper on a rotary disk until they fall right side up and then they are arranged in trays for feeding into the primer-inserting machines. Women are employed for this work, and after the trays are filled each one is visually inspected with a magnifying glass for defective primers. Six inspected trays are placed in small wooden cabinets and are turned over to the primer-inserting section. Primer-inserting is the last job under case manufacturing.

CARTRIDGE ASSEMBLY

A loading machine which fills the primed cartridge case with the propellant powder, inserts, seats, and crimps the bullet into the case, and lacquers the bullet point on tracer and armor-piercing with red or black, completes the operations on a round of ammunition.

Two types of loading machines are used, but both have a sequence of automatic operations which spread the mouth of the case, load and weigh the powder propellant, check the weight of the powder, insert the bullet, seat the bullet at the correct position, and crimp the case mouth in relation to the cannelure. On the straight-line loading machine the last operation switches the bullet into an upside-down position while the point is automatically lacquered and dried, and then drops it off as a complete round into a move truck ready for final inspection.

Both men and women are used as operators on these machines, the women operating those which load and assemble the .30- and .45-caliber rounds and the men the .50-caliber. A period of 5 or 6 weeks was reported as necessary to become proficient and familiar with the tending of these machines. The straight-line machine has automatic feeds for the cases, powder, and bullets. Tracer bullets are hand fed because in tumbling them from a hopper the tracer powder might become dislodged slightly and accidentally ignite. The operators who feed tracers wear gloves and work at a continuous speed of 60 to 80 a minute for .30-caliber and about 50 a minute on the .50-caliber. Two operators tend these machines, the one feeding and the other keeping the hoppers filled and watching the machine.

Women might be used on the other .50-caliber loading machines but it would be advisable to employ men to fill the powder magazines and the bullet and case hoppers, as the powder cans for the .50-caliber were reported as weighing about 30 pounds, or three times as much as for the .30-caliber, and the bullets and cases also are much heavier. The operators normally fill the hoppers and lacquer pots.

Tending the loading machine is a standing job. There are possible hazards of injuring fingers in removing defective cases from the machine, and fires and explosions may occur from the igniting of the tracer or the propellant powder. The machines are cleaned and blown out with compressed air at regular intervals during the day. The operator must have the nervous stability of being able to work without undue strain under more or less hazardous conditions.

INSPECTION

Detailed specifications have been developed for all the component parts and stages of production. Inspection for defects in material and manufacture goes on continuously. The finished cartridges are given a final inspection to make sure that all requirements have been met and these inspectors in the Government arsenal are not responsible to the small-arms divisions but to a special inspection department. Similar Government inspectors are employed in the operating plants and will be employed in the new plants.

Most of the inspectors are women. Much of the inspection is visual but there is considerable gage and machine checking. Descriptions of some specific inspection jobs follow.

Case inspection.

After the cases are completed and before the primers are inserted, all are inspected. A machine device which carries the cases from left to right on a screw conveyor with mirrors above and below permits the inspector to check the mouth and head of each case for visible defects. Other inspectors use gages, magnifying glasses, and checking aids. The lighting must be good, the workers sit, and there are no hazards. Acuteness and dexterity are required for this inspection and a training or learning period of 6 to 8 weeks is needed.

Both defective and approved cases are reinspected to make certain that defective cases are not accepted and that acceptable cases are not discarded. This worker must be a person of more experience than the original inspector, though the devices and machines used are similar.

Primer inspection.

Primers are inspected with the aid of magnifying glasses and the rejected ones are removed with small tweezers. One or two weeks of training to become familiar with the points for which inspections are made is all the training required. The work is exacting in that the individual units handled are very small. Since the primers are inspected in the room where they are made, and since they contain explosives, there are the hazards to which all explosives operators are subjected.

After the primers have been inserted in the cases, there is a special inspection of the insertion, crimping, and varnishing. This work is done near the primer-insertion machine and the worker stands. The cases are greasy, so gloves must be worn if the hands are to be protected from the oily film. Only a few days' training is needed.

Completed rounds of ammunition inspection.

Women operate an automatic inspection machine which checks the dimensions on six points and also the weight. The function of the operator is merely that of a machine feeder.

The preceding are typical of only a few of the types of inspection done and there are a great many other machine, gage, and visual checks made by women. Women do all the inspection except the drop-primer test, the mercury cracking test, and a few other technical testing jobs. Both the drop-primer test and the mercury cracking test could be done by women. The mercury cracking test is an accelerated chemical aging test to determine the possibility of cracks and splits in storage. A simple chemical routine is followed in making the test and could be done as well by women as by men. Gloves are worn to protect hands from nitric acid and mercurous nitrate. Since this is a random sample or spot-check of a few cases and cartridges of a large lot, the tester must be a careful and responsible person, as the acceptance or rejection of the entire lot may be determined by this test. Since a solution of mercurous nitrate (1 percent) is used there may be some hazard of mercury poisoning for the careless worker.

PACKING

Women are employed to set up cartons, to pack cartridges into small pasteboard containers and then into the larger cartons, and

hand-paste labels on the cartons. Men pack the cartons into metal-lined wooden boxes, solder the covers, and test for leaks. The final packing processes are too heavy for women, as boxes often weigh more than 100 pounds.

MISCELLANEOUS WOMEN'S JOBS

A number of jobs of minor employment significance held by women working in the Government arsenal visited were on rifle clips, pressure cylinders, and dummy ammunition.

Rifle-clip manufacturing.

Women blanked out the parts and springs for rifle clips which hold five rounds of ammunition. The machines were punch presses with automatic feed, each woman operating from two to four machines. One woman fed clips and another springs into an assembly machine which turned out the clips. On another special machine, five cartridges were packed in each clip. One woman fed the clips and the other the rounds of ammunition. These feeding operations were fast but there was no skill or special experience required.

Pressure-cylinder manufacturing.

A new job for women in the Government arsenal was the making of small pressure cylinders—about one-half inch in length and one-fourth in diameter—and about 20 women were employed in a corner of the tool room on work that had formerly been done by men. The women were operating small bench shearing machines cutting the cylinders, machine burring, and hand lapping the ends. Approximately 5,000 cylinders a day were being turned out by the women and their productive rate averaged about the same as that of the men who formerly did this work.

Dummy ammunition.

A few women were doing various jobs on dummy ammunition, chiefly drilling holes.

UNIFORMS

Though no regulation uniform is required for explosives workers in the Frankford Arsenal, women are urged to purchase two simple cotton uniform-dresses, one red and one blue, colors alternated weekly in an effort to insure the wearing of a freshly washed garment at the beginning of each week. Lightly starched cotton fabric, which is somewhat resistant to fire, is the standard for the approved garments. Clothing made of inflammable cellulose fabric is banned. The approved uniform at the arsenal is fashioned so that in case it becomes ignited it can be removed quickly. Hair nets as a safety precaution must be worn by all women to keep long hair from becoming entangled in moving parts of machinery, to keep stray locks from being attracted by the static of machinery, and as a protection in case of a sudden flare-up of powder which might ignite loose ends of hair. Cotton work gloves are worn by some of the machine operators and inspectors as a protection against cuts and the grease and oil of the machines and parts handled. All uniforms, gloves, and hair nets are provided and maintained by the workers.

SUPERVISION

The need of adequate supervision in an explosives shop was stressed at the arsenal. The departments are divided into small units with an immediate supervisor over each. The selection and training of women who can supervise other women is a problem in human relationships which must be studied and met in the new plants. The supervision of small groups on night shifts must not be relaxed but should be given as much or more consideration than that on day shifts.